AN

INQUIRY

INTO THE

EFFECTS OF LIGHT

IN

RESPIRATION:

SUBMITTED, AS

AN INAUGURAL ESSAY,

TO THE

EXAMINATION

OF THE

REV. JOHN EWING, S. T. P. PROVOST;

THE

TRUSTEES & MEDICAL FACULTY,

OF THE

UNIVERSITY OF PENNSYLVANIA,

On the thirty-first of May 1800.

FOR THE DEGREE OF

DOCTOR OF MEDICINE.

By JOSEPH TRENT, of Richmond, Virginia,

MEMBER OF THE PHILADELPHIA MEDICAL AND CHEMICAL SOCIETIES.

" Organization, ſenſation, ſpontaneous motion, and all the operations of life, only exiſt at the ſurface of the earth, and in places expoſed to the influence of light. Without it nature itſelf would be lifeleſs and inanimate. By means of light, the benevolence of the Deity hath filled the ſurface of the earth with organization, ſenſation and intelligence."

Elements of Chemiſtry, by M. Lavoiſier.

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1800.

TO

JOSEPH GALLEGO, Esq.

OF

RICHMOND,

THIS DISSERTATION

IS INSCRIBED

AS A SMALL, BUT SINCERE, TRIBUTE

OF GRATITUDE AND ESTEEM,

BY HIS OBLIGED FRIEND,

AND HUMBLE SERVANT,

J. TRENT.

TO

Col. WILLIAM HETH,

COLLECTOR OF THE DISTRICT OF BERMUDA HUNDRED,
VIRGINIA;

AND TO

Mr. JOHN RICHARD, Jun.

MERCHANT, PHILADELPHIA,

THIS INQUIRY

IS DEDICATED,

AS A MARK OF

RESPECT AND ESTEEM,

BY THE

AUTHOR.

AN

INQUIRY

INTO THE

EFFECTS OF LIGHT, &c.

BY light I mean that ſubtile fluid, which is emitted from luminous bodies and is poſſeſſed of very ſingular and important properties.

Conſidered, as to its phyſical or chemical operation, light is certainly one of the moſt beneficial ſubſtances in nature. It not only conduces by its ſtimulus to organic exiſtence, but as the medium of ſight, it is the ſource of the moſt numerous and pleaſurable of our perceptions; and upon its combinations depend ſome of the moſt beautiful and aſtoniſhing chemical phenomena.

No ſubject, therefore, can merit our attention more than the properties of this etherial ſubſtance, by means of which all the beauty and glory of creation are laid open to our view.

It is the influence of light in reſpiration,* that I wiſh to eſtabliſh in the following inquiry; for which purpoſe I will deliver my obſervations and experiments under the three following heads.

I. The colour of bodies depends upon combined light.

II. Light is a conſtituent element of oxygen gas.

III. The vermillion colour of blood depends, in part, upon the operation of light.

* I read a paper on this ſubject, before the Philadelphia Medical Society in February laſt, before I had ever ſeen or heard of the publication of Mr. Davy, in Beddoes' Medical Contributions.

SECTION I.

I. THE COLOUR OF BODIES DEPENDS UPON COMBINED LIGHT.

PREVIOUS to the diſcoveries of the immortal Newton, our conceptions of the nature of light and colours were very imperfect, and to many of the ancients, this curious and important branch of philoſophy, appeared to be involved in impenetrable darkneſs; for, in the opinion of Plato, to pry into the myſteries of light, was to encroach upon the prerogatives of Divinity.

Notwithſtanding its obſcurity, many conjectures were advanced on this ſubject by ſome of the older opticians.

The celebrated Des Cartes argued very rationally that colour was a modification of light; and after him many others thought the differences of colour depended upon the condenſation and rarefaction of this ſubtile etherial ſubſtance.

Their ſpeculations, however, though ſometimes ingenious and plauſible, were unſupported by experiment or any kind of evidence; and it was not till the time of Sir Iſaac Newton, that our ideas of light were by any means juſt or accurate.

By a multitude of the cleareſt and moſt deciſive experiments, this great man has ſatisfactorily unfolded many of the moſt important properties of light, and has left behind him a theory of light and colours, by the aſſiſtance of which, we are enabled to account for many phenomena, which were before inexplicable.

His doctrine of the materiality of light and of the different colours depending upon the different refrangibility of the rays of light, though founded on experiment, and ſupported by the moſt ingenious reaſoning, was ſtrenuouſly oppoſed by cotemporary and ſucceeding philoſophers, eſpecially by the celebrated Euler, who ſuppoſed light to conſiſt in vibrations propagated from luminous bodies through a ſubtile etherial medium.

This hypotheſis, though advocated with great zeal by M. Euler, is completely refuted by the friends of the Newtonian doctrine, eſpecially by Meſſrs. Michell and Melville, whoſe experiments and obſervations eſtabliſh moſt decidedly that light is a ſubſtance and not a quality.

It would not comport with the uſual limits of an inaugural eſſay, to enter further into a diſquiſition of this kind; I muſt therefore refer the reader to the ſeveral books on optics.

I believe it is generally agreed among philoſophers, that the diverſity of colours, and variety of ſhades, under which bodies preſent themſelves to our view, depend upon the operation of light. Many experiments have been made, and much ingenious reaſoning advanced in ſupport of this opinion.

Duhamel* demonſtrated long ago, that the colour and inward texture of ſome bodies are changed in conſequence of their being expoſed to light.

He found that the juice of a certain ſhell fiſh contracted a fine purple colour, when it was expoſed to the light of the ſun, and that the ſtronger the light, the more ſplendid was the colour. Pieces of cloth dipped in this juice, and expoſed to the ſun, became red, though they were incloſed in glaſs; but they ſuffered no change, if in the ſame expoſure they were covered by any thing that intercepted light.

After this, Beccarius† applied himſelf with diligence and ſucceſs, to the inveſtigation of this curious ſubject, and found by many experiments, that the colour of various ſubſtances was altered by expoſure to light, excluſive of heat or any other circumſtance.

* Prieſtley on viſion. Vol. II. p. 378.

† Ibid. Vol. II. p. 379.

That neither heat nor air contributed to the production of thoſe changes, was proved by repeating the ſame experiments in a much higher temperature in a darkened room, and by expoſing the ſubſtances in an exhauſted receiver; for under theſe circumſtances, the abſence or preſence of light, was obſerved to have very great influence on the reſults of the experiments. In the firſt, no change took place, whereas in the exhauſted receiver the ſubſtances underwent the ſame change when expoſed to light as before.

I ſhall relate, in the courſe of this inquiry, ſome experiments on blood, which corroborate thoſe of Duhamel and Beccarius, and I hope they will demonſtrate clearly and decidedly the colouring power of light.

The influence of light on organized beings is very remarkable. Animals deprived of it and living in dark places, loſe their colour and become white, as is obſervable in Arctic animals during the long nights, in the countries near the pole.

" Worms and grubs, Mr. Dorthes obſerves, which live in the earth or in wood, are of a whitiſh colour. The birds and flying inſects of the night, are likewiſe diſtinguiſhable from thoſe of the day, by the want of brilliancy of colour; and the difference

is equally marked between thoſe of the north and of the ſouth."

Animals which inhabit tropical climates, where the light is conſtant and intenſe, poſſeſs much deeper and more brilliant colours, than ſuch as live to the north. Wild animals by domeſtication, always loſe their dull and obſcure colours, and become much brighter, and more beautiful, in conſequence of a more frequent expoſure to the light of the ſun; and it is remarked, that the colour of our domeſtic animals during winter, is leſs bright, than in ſummer. Doctor Girtanner has obſerved, that animals which conceal themſelves for the the greateſt part of the year, in ſubterraneous dwellings, loſe their colour and become white; and that mice kept in a cage, in a dark room, have produced white mice.

The influence of light on vegetation, is ſtill more remarkable; for, by depriving plants of it, they not only loſe their delicate ſhades, but ſicken and die, and when in green-houſes, the light is admitted to them from a particular part, they incline towards it, as if to ſhew how *eſſential* this fluid is, to their exiſtence.

The importance of this ſubſtance, and its power of producing colour in plants, have been noticed by ſeveral authors. "Without the influence of light, ſays Chaptal, vegetables would exhibit but

one lifeleſs colour; they are deprived of their beautiful ſhades by the interception of this luminous fluid."* Agreeable to this writer, and M. Fourcroy,† vegetables are not only indebted to light, for their colour, but likewiſe for their ſmell, taſte, combuſtibility, maturity and the reſinous principle: And hence, that aromatic ſubſtances, reſins, volatile oils, and thoſe colouring matters, of ſo much value for their livelineſs and body, are peculiar to ſouthern climates, where the light is more pure, conſtant and intenſe.

The immortal Lavoiſier entertained the ſame opinion of the importance of this fluid with reſpect to vegetative exiſtence and its power of imparting colour to vegetables. "Experiments upon vegetation," he obſerves, give reaſon to believe, that light combines with certain parts of vegetables; and that the green of their leaves, and the various colours of their flowers, are chiefly owing to this combination. This much is certain, that plants which grow in darkneſs, are perfectly white, languid and unhealthy, and that to make them recover vigour and to acquire their natural colours, the direct influence of light is abſolutely neceſſary."‡

* Elements of Chemiſtry.

† Elements of Natural Hiſtory and of Chemiſtry.

‡ Elements of Chemiſtry.

Mr. Davy,§ has proved by experiment, that the colour of vegetables depends upon light, and that by depriving them of this fluid, they become white, though naturally of a deep colour. He found, that red roſe trees, when included from light, before their flowers began to appear, produced flowers almoſt white; and that flowers naturally white, if expoſed to a concentrated light, became highly coloured.

Fruits are alſo indebted to light, for their beautiful colours, and I have often obſerved, that that part of them, which is moſt expoſed to the ſun, is always of the deepeſt colour.

Deprived of light, vegetables not only loſe their delicate ſhades, but alſo their noxious properties. Some poiſonous plants, by the abſtraction of light, loſe their deleterious qualities, and become agreeable to the taſte, and even harmleſs when taken into the ſtomach. It is in this way, that gardeners prepare many vegetables for our tables. The celery, endive and other eſculent vegetables, by this treatment, loſe their green colour and active qualities, and become white and wholeſome articles of diet.

In common with the inferior order of beings, man himſelf is indebted to light for his colour, as well as the moſt numerous of his pleaſures.

§ Beddoes' Medical Contributions.

In tropical climates, where the light is ſtronger and more conſtant, the inhabitants are obſerved to be of a deeper colour, than thoſe who live to the north, under a much leſs powerful ſun. In Africa, the natives are black, while in the northern parts of Europe they are white, and between theſe two quarters of the globe, are to be found all the intermediate gradations of colour.

Our own ſeaſons afford us a ſtriking example of the colouring power of light. During the ſcorching heat of ſummer, when the light is very intenſe, our ſkins often become highly coloured or tanned, as we commonly expreſs it; whereas in winter, when the ſun is not ſo powerful, we loſe the colour acquired in ſummer, and become much fairer.

It is invariably found that ſuch parts of our bodies as are expoſed to light are coloured, while thoſe that are covered by our clothes, remain perfectly white. Ladies, who are leſs expoſed to the ſun, are fairer than men; and men in confinement ſoon loſe their florid complexions, if they are deprived of light.

I have obſerved that many of thoſe gentlemen, who go to the Eaſt-Indies, though fair when they leave this country, acquire very brown complexions before they return; which circumſtance, can only be aſcribed to the greater concentration and reflec-

tion of the light of the ſun from the water, in that warm climate.

In what manner colour is produced by the operation of light, I ſhall not pretend to explain; it is a ſubject ſtill involved in very great obſcurity. Whether it is by abſtracting oxygen or any other principle from the body, is not aſcertained with ſufficient certainty to warrant a concluſion.

The colour of the ſkin depends upon the colour of the rete mucoſum; which in the African is black, in the European white, while it is of an intermediate or copper colour in the American. Doctor Beddoes imagined that the black ſkin of the African, was produced by the abſtraction of oxygen from the rete mucoſum by light, and his experiments ſeem to favour this hypotheſis; for by expoſing the fingers of a negro in the oxiginated muriatic acid, which eaſily parts with its ſuperabundant oygen, they ſoon became white. Doctor Girtanner aſſerts, that white animals and plants are more irritable, than thoſe that are coloured; and irritability he proves to depend upon oxygen. By the abſtraction of light they loſe their colour, and become much more irritable in conſequence of an accumulation of this principle.

This theory of the operation of light, explains with eaſe and perſpicuity, the diverſity of colour

obſerved in different countries. The ſtronger the light and more conſtant its application, the greater will be the abſtraction of oxygen, and the deeper the colour produced. It is in this way, that the various colours of organized beings are accounted for; but the production of colour in inorganic ſubſtances, is not to be explained with the ſame eaſe by this hypotheſis, for great changes take place in ſome ſubſtances expoſed to light, in which the preſence of oxygen has never been detected.

Beſides the loſs of colour, which would inevitably follow the privation of light, our atmoſphere would be rendered uninhabitable, from the ſupply of pure air being cut off; in the production of which the operation of light is abſolutely neceſſary.

SECTION II.

II. LIGHT IS A CONSTITUENT ELEMENT OF OXYGEN GAS.

ACCORDING to M. Lavoiſier and other celebrated chemical philoſophers, pure air conſiſts of oxygen combined with caloric or the matter of heat. This doctrine has obtained very generally among chemiſts, and from it is drawn the preſent theory of reſpiration and combuſtion.

However eaſily explicable the phenomena of thoſe proceſſes may appear to be, by this theory of oxygen gas, I ſhall attempt to prove that light is one of its principles; and that it is partly to the action of this etherial ſubſtance, that ſome of the phenomena of reſpiration ought to be attributed.

That light enters into the compoſition of oxygen gas, I infer, from its analyſis and ſyntheſis. It is well known, that in every rapid decompoſition of pure air, light is liberated, and all our experiments to form acids and metallic oxyds, prove it to be one of the elements of pure air. By the combuſtion of carbone, hydrogene, and other ſimple

ſubſtances in oxygen gas, a large quantity of the moſt brilliant light is liberated; to account for which, we muſt either admit that it is a principle of this gas, which is diſengaged by its decompoſition, or adopt the opinion of Macquer, who ſuppoſed that the light was emitted from the burning body.

This celebrated chemiſt attempted to unite the pneumatic theory with that of phlogiſton, and by a doctrine drawn from the two, he certainly explained the phenomena of combuſtion with great eaſe and perſpicuity; but unfortunately for his theory, no experiments were adduced in ſupport of it.

The light emitted by the ſun, Macquer regards as the matter of fire, and that by admitting it as fixed in bodies, it conſtitutes the phlogiſton of Stahl. According to his theory, in every combuſtion, the oxygen gas diſengages the light or phlogiſton from inflammable bodies, and occupies its place.

It is a ſufficient refutation of this theory, that no phenomena prove or require its exiſtence; whereas, that of light being diſengaged from oxygen gas, not only ſolves the phenomena, but is directly drawn from a multitude of experiments.

We have no evidence of the exiſtence of light in carbone, hydrogene or iron; yet by the com-

buſtion of theſe ſubſtances in pure air, to form carbonic acid, water and the calx of iron, a great quantity of vivid light is liberated.

The following experiment, made by Mr. Davy, eſtabliſhes, in the moſt poſitive and unequivocal manner, that light is contained in oxygen gas.

"A ſmall gun lock, armed with an excellent flint, was ſnapped in a veſſel filled with oxygen gas. The particles of ſteel, ſeparated by colliſion, were the moſt brilliant that can be imagined; and theſe particles, examined by a magnifier, were found to be converted into black oxyd of iron. The ſame experiment was made in a veſſel filled with carbonic acid gas; the iron was fuſed, but no light was liberated."*

This experiment not only proves that light enters into the compoſition of pure air, but eſtabliſhes its exiſtence independent of caloric. From light and heat being generally concomitant, many philoſophers† have ſuppoſed, that they are cauſe and effect; but the above experiment, in conjunction with another, made in an exhauſted receiver, in

* Beddoes' Medical Contributions.

† "We are unable to determine, whether light be a modification of caloric, or caloric be, on the contrary, a modification of light."
Lavoiſier's Elements of Chemiſtry.

which no light appeared, yet the metal was fuſed, proves that light is not a modification of heat; and goes a great way, in my opinion, to eſtabliſh the non-exiſtence of caloric, or the matter of heat.

From many experiments made by Mr. Davy, and thoſe of Count Rumford,* on friction, I am diſpoſed to doubt the materiality of heat. An opinion, however, the reverſe of this is advocated by ſome of the firſt philoſophers in Europe.

The moſt powerful arguments have been adduced on both ſides of the queſtion; but it appears to me that the force of reaſoning and certainly the weight of experiment, are againſt the exiſtence of caloric.

This controverſy between men of ſuch diſtinguiſhed talents, affords a true, though melancholy proof of the imbecility of the human mind and of the imperfect ſtate of ſcience. When ſuch men as Black, Crawford, Lavoiſier and Rumford diſpute, who can decide? It would be preſumption in me to advance an opinion.

The materiality of heat is certainly queſtionable; and when probability is ſhaken, reaſon ſtrongly inclines to ſcepticiſm.

* Eſſays Political, Œconomical and Philoſophical. Vol. II.

Though I entertain doubts on this ſubject, I by no means deny, that heat is matter, and that it acts a very important part in the œconomy of the univerſe; on the contrary, I ſhall conſider it, as one of the elements of pure air.

By the experiments of M. Berthollet, light appears to have great affinity with oxygen, and contributes with caloric to change it into the ſtate of gas.

This theory of the conſtitution of pure air, quadrates beſt with moſt of our experiments, and by it, the phenomena of combuſtion and reſpiration admit of a more eaſy and ſatisfactory explanation.

The exiſtence of light in pure air, is alſo demonſtrated by ſynthetical experiments. The attraction of light for oxygen is ſo powerful, that few bodies which contain the latter principle in a looſe ſtate of combination, can hold it when expoſed to light.

It is proved by the experiments of Doctors Prieſtley, Injenhouz and Mr. Davy, that vegetables, when expoſed to ſolar light, decompoſe water and carbonic acid. The hydrogene of the water and carbone of the acid, are attracted by the vegetable, while oxygen is diſengaged in the form of gas, by combining with light.

It is by virtue of theſe affinities, that the pure air of our atmoſphere is continually renewed. Man and other animals, live only by the aſſiſtance of the vital air which they breathe; whereas vegetables imbibe and are nouriſhed by the air which animals vitiate in their reſpiration, and in return diſcharge torrents of vital air.

Thus we ſee by what ſimple and œconomical means, the numerous beings on the globe are ſupported. The two great claſſes of organized bodies depend for their exiſtence on the labours of each other, and they are both dependant on light.

This is not the only way by which we prove the recompoſition of oxygen gas. Many inorganic ſubſtances, which contain oxygen, give it out, when in contact with light. A bottle of oxiginated muriatic acid expoſed to the ſun, parts with its ſuperabundant oxygen; but if in the ſame expoſure, the bottle is covered with any thing that will intercept light, the acid ſuffers no change; and when heated in a dark place, Chaptal obſerves, is even reducible into gas without decompoſition. The nitric acid alſo, when expoſed to the ſun, affords oxygen gas; whereas heat alone volatilizes it, without decompoſition.

The muriate of ſilver and red oxyd of mercury,

part with their oxygen in the form of oxygen gas, when expoſed to the light of the ſun.

M. Lavoiſier obſerves, when ſpeaking of the reduction of red precipitate in a porcelain retort, "As the oxygen gas never appears till the retort becomes red, it ſeems to prove the principle eſtabliſhed by M. Berthollet, that an obſcure heat can never form oxygen gas, and that light is one of its conſtituent elements."

What a wonderful coincidence of facts, to prove that light is a component part of pure air!

The very author, who makes pure air to be a combination of oxygen and caloric, has in his definition of combuſtion, acknowledged light to be one of the principles of this air.

According to Lavoiſier, "Combuſtion is the decompoſition of oxygen gas, produced by a combuſtible body. The oxygen which forms the baſe of this gas, is abſorbed by, and enters into combination with, the burning body, while heat and light are diſengaged."

It will be unneceſſary for me to multiply inſtances of the compoſition and decompoſition of oxygen gas, to prove that light is one of its conſtituent elements.

SECTION III.

III. The vermillion colour of blood depends, in part, upon the operation of light.

HAVING demonſtrated, I hope, in the preceding parts of this inquiry, that light is a conſtituent principle of oxygen gas, and that moſt colours depend upon combined light; I will go on to prove by experiment, the operation of this ſubtile fluid on blood, eſpecially in contributing to produce its florid colour; from which circumſtance, and from the action of light on other bodies, I ſhall infer its influence in reſpiration.

According to the moſt popular theory of reſpiration, vital air is decompoſed in the lungs; the oxygen by combining with the blood occaſions its vermillion colour, while the caloric is ſet at liberty and produces animal heat.

If, agreeable to this doctrine, oxygen gas is decompoſed in the lungs, light muſt be liberated, as well as caloric, as we have made it appear that light is a component part of this gas. It is therefore, more eſpecially our object, in this place, to

eſtabliſh by experiments on blood and by deductions from analogy, the effects of this principle in reſpiration. Light from its extreme tenuity, is capable of paſſing unaltered through the pores of diaphanous bodies; I procured, therefore, very tranſparent phials to experiment with, and when I wiſhed to aſcertain the effects of light alone, every precaution was uſed to prevent the co-operation of other agents.

Experiment 1.

A vein of the arm was opened, and two phials, holding each two ounces, were filled with blood. Great pains were taken to prevent the contact of air, by applying the phials as near to the vein as poſſible, and by corking them as ſoon as they were filled. One of theſe phials was immediately expoſed to the ſun, which was ſhining very bright. The other was put away in a dark cloſet. After remaining in this ſituation for two hours, they were examined, and the following appearances were exhibited. The blood in the phial expoſed to ſolar light, had loſt its dark venous colour and was turned red, but the colour was not half as bright as when in contact with atmoſpheric air. That part of the blood which was ſhaded, in ſome degree, by reſting againſt the window, was not as bright as that which looked directly to the ſun, though it was altered conſiderably in colour.

The phial in the dark cloſet ſuffered no change.

As the blood was placed in the ſun, I entertained doubts, whether or not heat might have contributed to the change. To aſcertain this point, therefore, the following experiment was made.

Experiment 2.

A vein being opened, the ſtream of blood was directed into a two ounce phial, which was held as cloſe to the arm as poſſible, to avoid the contact of air. In this way three phials were filled and after being well corked, they were diſpoſed of in the following manner:

One was placed in the ſun, ſhining very bright, about 11 o'clock, A. M. another, after being covered with black, was likewiſe expoſed to the ſun: but the third was put away in the dark cloſet.

In two hours they were examined. The blood in the firſt phial was turned red, as in the preceding experiment; in the ſecond, which was expoſed as the firſt, but covered with black, the blood ſuffered no perceptible change; which was alſo the caſe with the third.

This experiment ſatisfied me that light and not heat, was the agent which produced the change,

for upon examining the two phials placed in the ſun, I found that the one covered with black was conſiderably warmer than the other, yet no alteration took place in the colour of the blood it contained; whereas the blood in the other, which was not ſo much heated, and from which light had not been excluded, ſoon acquired a red colour.

I can aſcribe, therefore, the want of colour in the ſecond phial, to nothing elſe but the interception of light by its black covering.

Though this experiment removed my doubts as to the cauſe of the change, yet as my friend and fellow-graduate, Mr. Robert Berkeley, who witneſſed the making of theſe experiments, ſtill believed in the co-operation of heat, I made the two following experiments, which prove moſt decidedly, the influence of light excluſive of heat, in colouring of blood.

Experiment 3.

Two phials, holding each two ounces, were filled with venous blood, and after being well corked, one of them was immerſed in ſnow on the outſide of a window, on which the ſun ſhone very bright. About one third of the phial from top to bottom, was expoſed to ſolar light, by ſcraping off a part of

the ſnow; while the reſt of it, was completely immerſed and excluded from light.

The other phial was placed as uſual, in the cloſet.

Upon inſpection two hours after, I found that part of the blood on which the light had fallen, was turned red, while the part oppoſite to this and ſecluded from light, though altered in colour, was not near as bright as that which looked immediately to the ſun.

The blood in the cloſet ſuffered no alteration.

Here the co-operation of heat could not be ſuſpected, for it is well known, that all bodies in paſſing from the ſolid to the fluid ſtate, as was the caſe with the ſnow, abſorb heat; therefore, the blood in this experiment, inſtead of acquiring, muſt have loſt its own heat, very ſoon after immerſion.

EXPERIMENT 4.

A vein of the arm was opened, and two phials were filled with blood from it, the uſual precautions being obſerved.

One covered with black, was placed before a fire, the warmth of which was as much as I could endure. The other was expoſed to the ſun, which ſhone with great ſplendour.

The blood before the fire was examined frequently for two hours and better, but no change in colour was obſerved to take place; whereas, that expoſed to the light of the ſun became altered in a very ſhort time, and at the expiration of two hours, it was as red as in the preceding experiments.

The influence of light, excluſive of heat or air, in colouring of blood, is unequivocally demonſtrated by theſe experiments, which have been repeated with preciſely the ſame reſults.

The blood turned red by light, if expoſed in darkneſs ſoon loſt its colour and became very black, and was not to be coloured again by re-expoſure to light, however intenſe.

I alſo remarked, that the blood which had remained in the dark cloſet for three or four hours, was with difficulty robbed of its black colour, and never contracted ſo bright a red as freſh blood, though the moſt concentrated light was applied.

What this could have been owing to, I know not; but think it probable, that during its cooling, the blood may have parted with ſome principle, or undergone ſome peculiar change, which indiſpoſed it to receive a red colour, from the action of light alone. We know that from blood juſt drawn a

conſiderable halitus ariſes, and after becoming cold, I have found its colour with difficulty changed, even by oxygen gas.

To aſcertain what would be the effect of expoſing blood in the ſame atmoſphere, but to different degrees of light, I made the following experiment.

Experiment 5.

Two ſmall china bowls were nearly filled with venous blood and the room was darkened by bringing too the window ſhutters. Through an aperture in the ſhutters, a ſmall quantity of very brilliant ſolar light was admitted, which fell upon and completely covered the ſurface of the blood in one of the bowls. The other bowl was placed by the ſide of this, but no light from the aperture was allowed to fall upon it.

In this ſituation they continued for two hours, when upon examining them, it was found, that the blood on which the light had fallen, was turned of a moſt brilliant vermillion colour; while that in the bowl which was expoſed in the ſame atmoſphere, but to a weaker light, had acquired a colour much leſs florid.

This experiment unequivocally demonſtrates the power of light in augmenting the vermillion colour

of blood, and taken in conjunction with the other experiments and obſervations contained in this inquiry, goes a great way, in my opinion, to eſtabliſh the influence of this etherial ſubſtance in reſpiration. Let us apply thoſe facts to explain ſome of the phenomena of this important function.

Reſpiration is conſidered, by phyſiologiſts, as an operation, by means of which oxygen gas is continually paſſing from the gaſeous to the concrete ſtate; it muſt therefore at each inſtant abandon the caloric (and light too) which held it in ſolution and in the ſtate of gas.

According to this theory, oxygen gas is decompoſed in the lungs; its baſe combines with, and gives a florid colour to the blood, while its caloric is ſet at liberty and produces animal heat. I believe in the decompoſition of pure air in reſpiration, but cannot agree that all the phenomena of this function are produced by oxygen and caloric; nor will the reader find any difficulty in admitting of the co-operation of light, if he will compare the preceding obſervations and experiments, with this doctrine, which is univerſally received. Combuſtion and reſpiration are ſaid to be two complex chemical proceſſes, whoſe phenomena are the ſame or very ſimilar. Now the liberation of light is admitted in combuſtion, by the advocates of the preſent theory, yet

they say nothing of its disengagement in respiration. If oxygen gas is decomposed in these two processes, certainly the principles of this gas must be liberated in both. In combustion, which is a more rapid decomposition of pure air, the disengagement of light is very evident to our senses; whereas in respiration it is impossible to have any such evidence, not only in consequence of the concealed situation of this process, but of the slower and more gradual decomposition of pure air in the lungs.

We can therefore judge only of the liberation and effects of light in respiration, by the nature of the air expired and by experiments on blood out of the body.

By the researches of the illustrious Priestley and Lavoisier, the composition of our atmosphere and the nature of the airs expired, have been fully developed. The air we respire is found to consist of azotic and pure air, in the proportion of 72 parts of the former to 28 of the latter, which undergoes very remarkable changes in the lungs.

Doctor Goodwin found, by experiments on himself, that the diminution of pure air and the increase of fixed air,* was considerable, in a single respiration; while the azotic air suffered neither increase nor diminution. Now if agreeable to the doctrine

* The air he breathed contained 2 parts in 100 of fixed air.

of Goodwin and Girtanner, the increaſe of fixed air, is owing to the oxygen of the decompoſed pure air, uniting with the carbone of the blood, it muſt of neceſſity follow that light is liberated, for we have proved by experiment,* that light does not enter into the compoſition of carbonic acid; nor have we any evidence of its being contained in azotic gas or in water, which is the other product of reſpiration.

A late ingenious writer, Mr. Davy, denies the decompoſition of vital air in reſpiration, and aſſerts that the liberated carbonic acid and water are conſtituent principles of venous blood, which are diſplaced by the vital air; for which the venous blood has a greater elective attraction, than for its conſtituent elements, water and carbonic acid.

Mr. Davy denies the exiſtence of caloric altogether, and makes oxygen gas to conſiſt of light and oxygen, to which he has given the name of phoſoxygen.

As the reader may not have ſeen this gentleman's paper, I will give a ſhort view of his theory.

" Reſpiration, he obſerves, is a chemical proceſs, the combination of phoſoxygen, with the venous blood in the lungs, and the liberation of carbonic acid and aqueous gas from it. From the combina-

* Vid. p. 21.

tion and decompoſition ariſes an increaſe of repulſive motion, which, combined with that produced by the other chemical proceſſes taking place in the ſyſtem, and that generated by the reciprocal action of the ſolids and fluids, is the cauſe of animal heat; a heat which the other ſyſtems have ſuppoſed to ariſe chiefly from the decompoſition of oxygen gas, oxygen and caloric."*

Mr. Davy ſuppoſes, that the florid colour of blood is produced by phoſoxygen combining with it, in its entire ſtate, and urges the following objections to the decompoſition of pure air in reſpiration.

Carbone, hydrogene and iron, he ſays, never decompoſe oxygen gas at ſo low a temperature as 98° and that it is never decompoſed by thoſe ſubſtances, without combuſtion, flame and great heat.

This is aſſuming more, I apprehend, than daily obſervation and experience authorize, for we know that the combinations of oxygen are decompoſed by many ſubſtances in a temperature much lower than that of the human body. Several of the metals are calcined by expoſing them in a moiſt atmoſphere, without any perceptible liberation of light or heat. In fermentation and putrefaction, large quantities of carbonic acid are formed and extricated in a temperature much inferior to that of the lungs and without combuſtion or flame. His objections, there-

* Beddoes' Medical Contributions.

fore, to the decompoſition of oxygen gas, in reſpiration are not founded. But admitting for a moment, that oxygen gas cannot be decompoſed in ſo low a heat as 98°, in our laboratories, are we from thence to infer, that the lungs have not the power of decompoſing it? Do not vegetables decompoſe water and carbonic acid, with the utmoſt facility, in the ordinary temperature of our atmoſphere? Have we any experiments that prove the principles of water and carbonic acid to be in a weaker ſtate of combination, than thoſe of oxygen gas? Since then vegetables can decompoſe ſome of the ſtrongeſt combinations of oxygen, why deny a ſimilar faculty to a more perfect order of organized beings? Is it wiſe in us to eſtimate the powers of the animal œconomy, by thoſe of an imperfect art? Certainly not; for the more we inveſtigate the ſtructure and operations of animated beings, the more are we ſtruck with the faculties they poſſeſs, and convinced of the wiſdom of their Creator!

I have no doubt of the decompoſition of oxygen gas in reſpiration, but cannot aſcribe all the phenomena of this important function to the excluſive action of oxygen and caloric, as moſt chemical philoſophers have done.

I conclude, therefore, and think my concluſion is warranted by the preceding obſervations and experiments, that light is a conſtituent element of oxygen

gas, and that it is to the diſengagement* and operation of this ſubſtance in reſpiration, that ſome of its phenomena ought, in part, to be attributed, more eſpecially the vermillion còlour of pulmonary blood.

There is no knowing what diſcoveries may be made in this important ſubject, by a more extenſive chemiſtry. By the reſearches of Prieſtley, Lavoiſier and other celebrated chemiſts, many of the elements are already known to us, and it is to be hoped that by a continuance of their labours, the nature of thoſe ſubtile fluids will be diſcovered, which at preſent elude the perception of our ſenſes and are only known to us by their direful effects.

* May not the electroid fluid be produced in this way? Is electricity any thing more than "light in a condenſed ſtate?"

FINIS.